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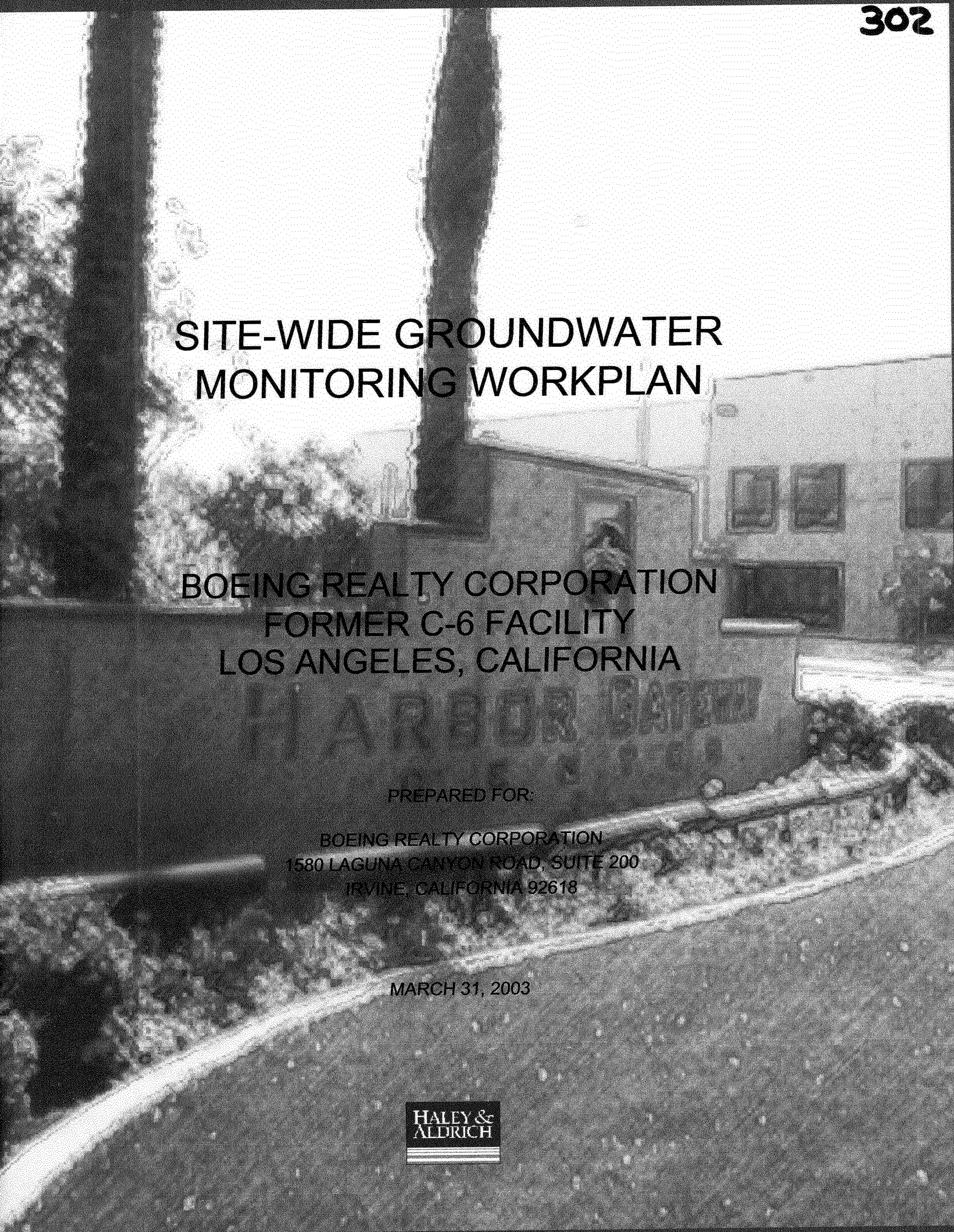

SITE-WIDE GROUNDWATER MONITORING WORKPLAN

BOEING REALTY CORPORATION
FORMER C-6 FACILITY
LOS ANGELES, CALIFORNIA

PREPARED FOR:

BOEING REALTY CORPORATION
1580 LAGUNA CANYON ROAD, SUITE 200
IRVINE, CALIFORNIA 92618

MARCH 31, 2003

HALEY & ALDRICH

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BOEING

4 April 03
C6-BRC-T-03-005

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
Los Angeles Region
320 W. 4th Street, Suite 200
Los Angeles, CA 90013

Attention: John Geroch

Subject: **SITEWIDE GROUNDWATER MONITORING WORKPLAN, BOEING REALTY CORPORATION, FORMER C-6 FACILITY, 19503 SOUTH NORMANDIE AVENUE, LOS ANGELES, CA**

Dear Mr. Geroch:

Please find enclosed for your review, a copy of the subject document prepared by Haley & Aldrich for Boeing Realty Corporation.

If you have any questions concerning this document, please contact the undersigned at 562-593-8623.

Sincerely,

Stephanie Sibbett
Boeing Realty Corporation

Cc: Mario Stavale, Boeing Realty Corporation
Dwight Merriman, RREEF

enclosure

SITE-WIDE GROUNDWATER MONITORING WORK PLAN
FORMER C-6 FACILITY
LOS ANGELES, CALIFORNIA

by

Haley & Aldrich, Inc.
San Diego, California

for

Boeing Realty Corporation
Long Beach, California

File No. 28882-002
March 31, 2003

HALEY & ALDRICH

SITE-WIDE GROUNDWATER MONITORING WORKPLAN

BOEING REALTY CORPORATION
FORMER C-6 FACILITY
LOS ANGELES, CALIFORNIA

Prepared for

BOEING REALTY CORPORATION
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1.0 INTRODUCTION

Groundwater impacts at Boeing Realty Corporation's (BRC) Former C-6 Facility (Site) in Los Angeles, California (Figure 1) have been identified and delineated through various groundwater investigation and monitoring programs. Two primary groundwater impact source areas have been identified: Former Building 1/36 and Former Building 2. Three off-site sources have also been identified. The International Light Metals (ILM) site exists to the west, the Former Montrose Chemical site (Montrose) exists to the south, and the Former Del Amo facility exists to the east of the Site. The reported impacts consist primarily of volatile organic compounds (VOCs). The purpose of this workplan is to establish a Site-wide groundwater monitoring network based on delineated groundwater impacts that will provide data for:

- Monitoring plume concentrations over time;
- Verifying plume stability;
- Monitoring the effectiveness of groundwater remediation efforts;
- Documenting monitored natural attenuation (MNA) processes; and
- Evaluating groundwater quality data relative to plumes at the adjacent ILM, Montrose, and Del Amo facilities.

The following sections present Site background, discuss the Site groundwater quality, the Site conceptual model, and propose a groundwater monitoring network and implementation plan for accomplishing these objectives.

2.0 BACKGROUND

The Site consists of four parcels, A through D (Figure 2). The Site occupies approximately 170-acres, and was used for aircraft manufacturing from 1952 through 1992. Parcels A, B, and D are in advanced stages of redevelopment; Parcel C is in the initial phase of redevelopment. Since Site remediation activities have altered surface elevations by grading, all vertical measurements presented in this workplan are presented in feet above mean sea level (MSL).

Groundwater at the Site has been characterized through numerous investigative efforts and groundwater monitoring events over the past 15 years. Delineation of Site groundwater impacts are detailed in the Site-Wide Groundwater Assessment Report (Haley & Aldrich, Inc., 2002a). The basis of the groundwater delineation effort is over 40 groundwater monitoring wells, and over 120 depth-discrete groundwater grab samples (Simulprobes). Over the past few years, 19 of the wells have since been removed as a result of redevelopment activities.

Groundwater at the subject property is primarily impacted by VOCs. The primary VOCs present at the Site, and the percentage of Site wells they occur in are listed below.

- Trichloroethene (TCE) (98%), and
- 1,1-Dichloroethene (1,1-DCE) (73%).

Based on the distribution and concentrations of VOCs observed, TCE and 1,1-DCE are considered the primary VOCs at the Site.

Three VOCs that were also detected at elevated concentrations in numerous locations are considered the secondary VOCs (Haley & Aldrich, 2002a). These VOCs and the percentage of Site wells they occur in are listed below.

- cis-1,2-Dichloroethene (cis-1,2-DCE) (51%),
- 1,1,1-Trichloroethane (1,1,1-TCA) (43%), and
- 2-Butanone (or Methyl Ethyl Ketone [MEK]) (14%).

The secondary VOCs have generally been detected, and are co-located within the primary VOC plumes. The Site has been broken down into three primary areas (Figure 2) based on historical use and areas of VOC impacts. These areas include:

- Building 1/36 Source Area
- Building 2 Source Area
- Site-Perimeter Groundwater Quality (including Off-Site Sources)

Remediation for these two VOC source areas by enhanced bioremediation has been approved by the Los Angeles Regional Water Quality Control Board (LARWQCB), and will be implemented in 2003 and 2004, concurrently with Site redevelopment.

2.1 Local Setting

The Site is located at 19503 South Normandie Avenue in Los Angeles, California (Figures 1 and 2). The Site occupies approximately 170 acres and is bound by the following major streets and properties:

- 190th Street to the north;
- Normandie Avenue and the Del Amo Superfund Site to the east;
- Montrose Chemical Superfund Site (Montrose), Jones Chemical, and Stauffer Chemical to the south; and
- International Light Metals (ILM) to the west.

2.2 Geology and Hydrogeology

2.2.1 Regional Geology and Hydrogeology

The principal hydrogeological units in the Site vicinity are the Lakewood Formation and San Pedro Formation. A summary of regional geologic formations is shown in the table below:

Formation	Hydrostratigraphic Unit	
Lakewood Formation (Upper Pleistocene)	Bellflower Aquitard	Upper Bellflower Aquitard (UBA)
		Middle Bellflower Sand (MBFB, MBFM, MBFC, MBFB/C)
		Lower Bellflower Aquitard (LBF)
	Gage Aquifer	
San Pedro Formation (Lower Pleistocene)	Gage Lynwood Aquitard (GLA)	
	Lynwood Aquifer (LYNWOOD)	
	Unnamed Aquitard	
	Silverado Aquifer	

2.2.2 Local Geology and Hydrogeology

The hydrogeology at the Site has been defined on the basis of data derived from the following: monitoring well drilling, construction, testing and sampling, exploration boring drilling and sampling, cone penetrometer testing, and Simulprobe boring and sampling.

A Semi-Perched Aquifer is reported to be present in the vicinity of the Site (California Department of Water Resources [CDWR], 1961); however, based on correlation of Site stratigraphic data with the data from adjacent Sites, it appears that the Semi-Perched aquifer is absent at the Site.

The hydrogeologic units assessed at the Site are members of the Upper Pliestocene, Lakewood Formation and are identified in descending order as:

- Upper Bellflower Aquitard (UBF),
- Middle Bellflower Sand (MBF), and
- Lower Bellflower Aquitard (LBF).

Exploration borings CPT-1-1, CPT-1-2, CPT-2-1, and CPT-2-2 provided the primary basis for assessing the nature and extent of the hydrogeologic units beneath the Site. These borings were geotechnically logged, and continuous soil sampling and logging was conducted at each location in the depth interval from 60 to approximately 120 feet or more.

2.2.2.1 Upper Bellflower Aquitard

The UBF is a predominately fine-grained hydrogeologic unit. The UBF is a heterogeneous mixture of low permeability silts and clays with fine-grained sands. The UBF unit is continuous beneath the Site. The UBF extends downward from the land surface to an elevation of approximately 14 to 25 feet below MSL.

The UBF generally occurs above the water table at the Site, and therefore all but the lowermost UBF is unsaturated. The UBF makes up the vadose zone at the Site and as a result, hydraulic properties of the UBF have not been estimated.

2.2.2.2 Middle Bellflower Sand

The MBF is a heterogeneous unit primarily comprised of fine to medium sand underlying the UBF. The MBF is continuous beneath the Site. A notable fine-grained sub-unit divides the MBF into two sands locally beneath the Site. In general, the MBF is the uppermost-saturated, relatively permeable unit beneath the Site.

The MBF has been further divided locally to include:

- the Middle Bellflower B-Sand (MBFB),
- the Middle Bellflower Mud (MBFM), and
- the Middle Bellflower C-Sand (MBFC).

B-Sand

The B-Sand (or MBFB) consists principally of fine to medium grained sand and silty and with lessor silts and clays. The B-Sand is continuous beneath the Site with a thickness on the order of 25 to 30 feet. The thickness of the MBFB may range up to approximately 40 feet locally where the Middle Bellflower Mud is absent and the B-Sand has merged with the Middle Bellflower C-Sand. The top of the B-Sand coincides with the base elevation of the UBF, and the elevation of the bottom of the B-Sand is indicated to range from approximately 35 to 50 feet below MSL where the Middle Bellflower Mud is present.

Upper and lower zones of the B-Sand have been defined for the purpose of further defining the vertical distribution of groundwater quality. The upper B-Sand has been defined in the elevation range between 17 and 25 feet below MSL, and the lower B-Sand has been defined in the elevation range between 31 and 46 feet below MSL.

Hydraulic properties of the B-Sand have been estimated from six slug tests performed by Woodward- Clyde Consultants (WCC), one pumping test conducted at monitoring wells by WCC, and one water injection test performed by Arcadis G&M on a series of small-diameter bioenhancement points. Estimates of B-Sand hydraulic conductivity derived from slug test data have been reported to range from 24 to 140 gallons per day per square foot (gpd/ft^2). Estimates of hydraulic conductivity derived from the pumping test data were reported to range from 460 to 970 gpd/ft^2. The storage coefficient was reported to range from 0.004 to 0.0013 (Kennedy Jenks Consultants [KJC], 2000, and WCC, 1990). Estimates of hydraulic conductivity from the water injection test were reported to be between 77 to 120 gpd/ft^2 (0.00367 to 0.00577 centimeters per second [cm/sec]) (Arcadis G&M, 2002c). Based on the results of these tests, the hydraulic conductivities derived by the slug tests and water injection tests correlate well, and range from 24 to 140 gpd/ft^2. Hydraulic conductivity values derived from the pumping test were considerably higher, and range from 460 to 970 gpd/ft^2. Since these tests were performed in different wells and at different locations of the Site, correlation of the data is difficult.

MBFM

The MBFM is low permeability, heterogeneous, and consists predominately of silts and clays with subordinate percentages of sand. Thickness of the MBFM ranges from approximately three feet up to approximately 13 feet. The elevation of the top of the MBFM coincides with the bottom elevation of the B-Sand, and the base of MBFM is indicated to range from approximately 45 to 55 feet below MSL. Hydraulic properties specific to the MBFM have not been determined at the Site.

C-Sand

The lowermost sands of the Middle Bellflower Sand where the MBFM are present have been defined as the C-Sand (or MBFC). Similar in lithology to the B-Sand, the C-Sand consists principally of fine to medium grained sand and silty sand with lessor silts and clays. The C-Sand is generally continuous beneath the Site, but is apparently merged with the overlying Middle Bellflower B-Sand, where the Middle Bellflower Mud is absent. The thickness of the C-Sand ranges from 13 to 21 feet in the Site exploration borings. The top elevation of the C-Sand is equivalent to the base of the Middle Bellflower Mud. The bottom of the C-Sand is indicated to range from 66 to 90 feet below MSL.

Hydraulic properties have not been determined for the C-Sand at the Site. Estimates of hydraulic conductivity are reported for slug tests at on-site, deep, monitoring wells WCC-1D and WCC-3D. However, the hydrostratigraphic data derived from the exploration borings (CPT investigation by Haley & Aldrich, Inc., Haley & Aldrich, 20002a) indicate that these wells were completed in the Lower Bellflower Aquitard; therefore, the slug test data is not representative of the C-Sand.

2.2.2.3 Lower Bellflower Aquitard

The LBF is predominately a low-permeability, fine-grained unit that underlies the Middle Bellflower Sand. The LBF is heterogeneous and consists primarily of silts and clays with lesser sands. The LBF is indicated to be continuous beneath the Site.

The thickness of the LBF was not evaluated with Site exploration borings. Exploration boring CPT-1-2 was advanced approximately 9 feet into the LBF. Data from assessments in the vicinity of the Site indicate that the LBF ranges from less than 10 to over 40 feet thick in the area (KJC, 2000, and Dames & Moore, 1998). The top elevation of the LBF coincides with the base of the MBFC. Hydraulic properties for the LBF have not been determined at the Site.

2.2.3 Groundwater Elevations and Gradients

Groundwater elevations in the uppermost groundwater at the Site in January 2001 ranged from approximately 13 to 15 feet below MSL, which is approximately 65 to 67 feet bgs. The presence of groundwater at the Site and its direction of flow have been principally defined on the basis of water level measurements at monitoring wells. Forty-three monitoring wells have been constructed at the Site. Nineteen of those wells have been subsequently abandoned. The majority of the wells at the Site have been constructed with well screens in the uppermost part of the B-Sand. Two deep monitoring wells (WCC-1D and WCC-3D) were constructed at the Site, which have since been abandoned. Stratigraphic data derived from four exploration borings at the Site indicates that those wells were screened in the LBF.

Water level measurements have been conducted at the Site since 1987. Water level contours for the uppermost groundwater at the Site are presented in Figure 4, and were developed from measurements obtained during September 2002 (Haley & Aldrich, Inc., 2002b). This figure represents the most recent water level data at the Site, and serves as the basis for discussing the groundwater elevation and direction of horizontal flow. Groundwater elevations in the uppermost groundwater at the Site in September 2002, ranged from approximately 12 to 16 feet below MSL, which is approximately 64 to 68 feet bgs.

2.2.3.1 B-Sand

Water level measurements performed during January 2001 at Site monitoring wells provide the basis for defining the occurrence and movement of groundwater in the B-Sand. In January 2001, groundwater level elevations in the B-Sand ranged from approximately 13 to 15 feet below MSL. The overall direction of horizontal groundwater flow in the B-Sand beneath the Site is to the south. Groundwater flow in the eastern and western margins of the Site is indicated to be to the south-southwest and south-southeast, respectively. The overall horizontal hydraulic gradient across the Site is on the order of 0.001 feet per foot.

2.2.3.2 C-Sand

Groundwater level measurements performed at two previous on-site deep monitoring wells (WCC-1D and WCC-3D), and data obtained from off-site wells completed in the C-Sand provide the basis for defining the occurrence and movement of water in the C-Sand (KJC, 2000 and Haley & Aldrich, Inc., 2002a). Groundwater level elevations in the C-Sand appear similar overall to the on-site B-Sand. The overall hydraulic gradient is on the order of 0.001 feet per foot.

A slight downward vertical hydraulic gradient may be present from the B-Sand to the underlying portions of the Bellflower Aquitard, including the C-Sand, based on water level measurement in the vicinity of well pairs WCC-1S/WCC-1D and WCC-3S/WCC-3D. The estimated vertical gradient ranges from approximately 0.002 to -0.009 feet per foot (Haley & Aldrich, Inc., 2002a).

The following section describes the groundwater quality in the B-Sand and C-Sand units of the Bellflower Aquitard.

3.0 GROUNDWATER QUALITY

The VOC impacts discussion presented below is related to source areas and Site-wide groundwater quality, and is based on 15 years of groundwater monitoring data from 43 groundwater monitoring wells, as well as 172 depth discrete groundwater grab samples. Details of the source-area groundwater investigation are included in the Site-Wide Groundwater Assessment Report (Haley & Aldrich, Inc., 2002a).

The following sections describe the Building 1/36, Building 2, and Site perimeter groundwater conditions.

3.1 Building 1/36 Source Area

The first area of elevated primary and secondary VOCs in groundwater is referred to as the Building 1/36 area, and generally includes Building 36 and the northeast portion of Building 1, and extending south to the northeast portion of Building 2.

3.1.1 Suspected source(s)

The primary suspected source areas for elevated groundwater impacts in the Building 1/36 plume are soil impact areas identified beneath Building 36, the northeast portion of Building 1, and the southeast portion of Building 1. The highest concentrations of VOCs in groundwater within the Building 1/36 plume are present in these general areas. These impacts are primarily related to a chemical storage complex located in Building 36, and a series of solvent underground storage tanks (USTs) located between Building 1 and Building 36.

3.1.2 Primary and Secondary VOCs

TCE is one of the primary VOCs, and has been detected at concentrations up to 97,000 micrograms per kilogram (μg/kg) in soil samples, and up to 21,000 μg/l in groundwater samples collected from monitoring wells and the multi-depth sampling program. 1,1-DCE is the other primary VOC, and has been detected up to 24,000 μg/l in groundwater samples. The secondary VOCs identified in the Building 1/36 groundwater plume are 1,1,1-TCA, toluene, and 2-butanone.

3.1.3 Concentrations/Extent of Impact

The primary and secondary VOC concentrations, and the extent of groundwater impacts within the Building 1/36 area have been assessed based on groundwater samples from 16 monitoring wells and 42 multi-depth Simulprobe samples. Isoconcentration contours are presented for TCE and 1,1-DCE, the primary VOCs in the Building 1/36 area, illustrating the concentration distributions and the lateral extent of groundwater impacts for various depths (Figures 5 through 8).

Vertical distributions of primary and secondary VOC concentrations, and the vertical extent of groundwater impacts are illustrated by cross sections and by individual isoconcentration contours for the Middle Bellflower Sand units. Figure 9 shows the cross-section locations and Figures 10 and 11 illustrate the vertical distribution of TCE, one of the primary VOCs in the Building 1/36 area.

The overall shapes of the primary and secondary VOC plumes appear consistent with the known soil source areas and predominant southerly groundwater flow direction in the Building 1/36 area. The lateral extent of the plumes in the B-Sand have been delineated, and the areas of elevated VOCs resulting from historical Site activities are currently confined to the Site. One area of elevated TCE concentrations in the Bellflower Aquitard is present along the western Site boundary. These impacts have migrated onto the Site from the ILM facility. The overall lateral extent of the primary and secondary VOC plumes in the C-Sand is significantly smaller than in the B-Sand, and at lower concentrations.

The following sections discuss the VOC impacts of the Building 1/36 B-Sand and C-Sand sub-units.

3.1.3.1 Building 1/36 B-Sand

The lateral and vertical limits of groundwater VOC impacts in the B-Sand are defined with the highest concentrations present under the soil source area between Buildings 1 and 36 in the upper B-Sand. This conclusion is based on data from 12 groundwater monitoring wells and 10 depth-discrete Simulprobe grab samples in this area (Figures 5 and 6). Maximum concentrations of the primary and secondary VOCs detected in the B-Sand in this area include TCE (12,000 micrograms per liter [μg/l]), 1,1-DCE (30,000 μg/l), 1,1,1-TCA (10,000 μg/l), 2-butanone (280,000 μg/l), and toluene (93,000 μg/l). Cis-1,2-DCE is also present (up to 660 μg/l), suggesting TCE biodegradation. Figures 5 and 6 illustrate the distribution of TCE and 1,1-DCE in the B-Sand. Figure 10 illustrates the vertical distribution of TCE in the B-Sand. The VOC groundwater plume in the B-Sand extends from the soil source area due south with the prevailing groundwater flow direction.

Primary and secondary VOCs were also delineated in the lower B-Sand through the collection of 15 depth-discrete Simulprobe grab samples. No groundwater monitoring wells are present in the lower B-Sand. Based on this data, concentrations of VOCs in the lower B-Sand are significantly lower than the upper B-Sand. Maximum concentrations of the most prevalent VOCs detected in the lower B-Sand in this area include TCE (6,100 μg/l), 1,1-DCE (6,600 μg/l), 1,1,1-TCA (22,000 μg/l), 2-butanone (93,000 μg/l), and toluene (27,000 μg/l). Cis-1,2-DCE is also present (up to 850 μg/l), suggesting TCE biodegradation. Additional details and figures of the lower B-Sand impacts are included in the Site-Wide Groundwater Assessment Report (Haley & Aldrich, Inc., 2002a).

3.1.3.2 Building 1/36 C-Sand

The lateral extent of primary and secondary VOC impacts in the C-Sand were assessed through the collection of 15 depth-discrete Simulprobe grab samples (Figures 7 and 8). Maximum concentrations of the most prevalent VOCs detected in the C-Sand include TCE (2,900 µg/l), 1,1-DCE (15,000 µg/l), 1,1,1-TCA (11,000 µg/l), 2-butanone (43,000 µg/l), and toluene (26,000 µg/l). The overall size of the C-Sand VOC impact area is much smaller than the B-Sand, and the concentrations are, in general, significantly lower. The longitudinal axis of the C-Sand VOC plume appears to be oriented to the southeast. Since no groundwater monitoring wells are completed within the C-Sand, the actual Site groundwater flow direction is not known. This plume orientation is however consistent with a reported southeast C-Sand groundwater flow direction at adjacent sites. The vertical distribution of TCE in the C-Sand is illustrated in Figure 10.

3.2 Building 2 Source Area

The second area of elevated primary and secondary VOCs in groundwater generally includes the northwest portion of Building 2, and extends south and southwest to the south-central portion of Building 2. This area of elevated groundwater impacts has been designated the Building 2 area.

3.2.1 Suspected source(s)

The primary suspected source areas for elevated groundwater impacts in the Building 2 plume are soil impact areas apparently related to former metal finishing processes and releases from one or more wastewater clarifiers. The highest concentrations of VOCs in groundwater within the Building 2 plume are present in this general area. Soil vapor extraction (SVE) remediation has been performed on the deep soil (greater than 12 feet bgs) impacts in this area, and a no further action determination was issued by the LARWQCB (LARWQCB, 2003).

3.2.2 Primary and Secondary VOCs

Based on the concentrations of VOCs identified in groundwater samples collected from monitoring wells and the multi-depth sampling program, the primary VOC identified in the Building 2 source area is TCE. The secondary VOCs are 1,1-DCE and chloroform.

3.2.3 Concentrations/Extent of Impacts

The primary and secondary VOC concentrations, and the extent of groundwater impacts within the Building 2 area have been assessed based on groundwater samples from 9 monitoring wells and 66 multi-depth Simulprobe samples. Isoconcentration contours are presented for TCE and 1,1-DCE in the Building 2 area, illustrating the concentration distributions and the lateral extent of groundwater impacts (Figures 5 through 8).

Vertical distributions of primary and secondary VOC concentrations, and the vertical extent of groundwater impacts are illustrated by cross sections and individual isoconcentration contours for the Middle Bellflower Sand units. Figure 9 shows the cross-section locations. Figures 10 and 11 illustrate the vertical distribution of TCE, the primary VOC in the Building 2 area.

The overall shape of the primary and secondary VOC plumes appears consistent with the known soil source areas and predominant groundwater flow direction. Lateral migration of VOCs in Middle Bellflower Sand within the Building 2 plume area appears to be towards the southeast. In particular, elevated concentration areas of primary and secondary VOCs in groundwater appear to migrate progressively southeast with depth. The overall lateral extent of the VOC plumes, particularly TCE in the C-Sand, are similar in size, but at lower overall concentrations, and southeast of the suspected source areas.

3.2.4 Building 2 B-Sand

The lateral limits of groundwater VOC impacts in the upper B-Sand are defined with the highest concentrations present under the soil source areas in the northwestern area of Building 2, where the metal finishing equipment and waste clarifiers were previously located.

This conclusion is based on data from nine groundwater monitoring wells and 22 depth-discrete Simulprobe grab samples in this area (Figures 5 and 6). Maximum concentrations of the primary and secondary VOCs detected in the upper B-Sand in this area are TCE (13,000 μg/l) and 1,1-DCE (560 μg/l). The VOC plume in the B-Sand extends from the soil source area to the southeast, with the prevailing southeasterly groundwater flow direction in the area of the Site (Figures 5 and 6).

Primary and secondary VOCs were also delineated in the lower B-Sand through the collection of 22 depth-discrete Simulprobe grab samples. No groundwater monitoring wells are present in the lower B-Sand. Based on this data, concentrations of primary and secondary VOCs in the lower B-Sand are significantly lower than the upper B-Sand. Maximum concentrations of the primary and secondary VOCs detected in the lower B-Sand in this area include TCE (3,900 μg/l) and 1,1-DCE (81 μg/l). The vertical distribution of TCE in the B-Sand is illustrated in Figure 11.

Additional details and figures of the lower B-Sand are included in the Site-Wide Groundwater Assessment Report (Haley & Aldrich, Inc., 2002a).

3.2.5 Building 2 C-Sand

The lateral extent of primary and secondary VOC impacts in the C-Sand was delineated through the collection of 21 depth-discrete Simulprobe grab samples (Figures 7 and 8). Maximum concentrations of the most prevalent VOCs detected in the C-Sand include TCE (6,100 μg/l), toluene (410 μg/l), and chloroform (240 μg/l).

Based on the data from the source-area reconnaissance investigation, the VOC plume in the C-Sand is lower in overall concentration than the impacts in the B-Sand. Figure 11 illustrates the vertical distribution of TCE in the C-Sand. The longitudinal axis of the C-Sand plume appears to be oriented to the southeast; however, there are no groundwater monitoring wells in the Building 2 area C-Sand to verify a southeast groundwater flow direction. Groundwater flow in the C-Sand at the ILM facility to the west of the Site is towards the southeast (TRC, 1999).

3.3 Site-Perimeter Groundwater Quality

Perimeter groundwater quality includes the areas of the Site that contain primary or secondary VOCs or other compounds in groundwater that are not within the Building 1/36 or Building 2 source areas. Groundwater impacts in these areas are typically lower in concentration and are difficult to directly link to an identified soil impact area. These areas also include groundwater quality impacts from adjacent sites with documented groundwater quality issues (Montrose, ILM, and Del Amo).

Site-perimeter groundwater quality in the B-Sand and C-Sand has been assessed over the past 15 years through the installation of 10 groundwater monitoring wells in the B-Sand and 20 depth-discrete Simulprobe grab samples in the B- and C-Sands. Groundwater monitoring wells used for perimeter monitoring include: WCC-5S, WCC-9S, TMW-10, TMW-11, TMW-14, XMW-08, XMW-09, XMW-18, XMW-19, BL-3, and DAC-P1 (Figures 4 through 11).

The purpose of the Site-perimeter groundwater monitoring wells and depth-discrete Simulprobe grab samples was to verify that the Site-related source-area impacts have not migrated off-site, and to document the migration of plumes from adjacent properties onto the Site. Based on the data provided by the 11 groundwater monitoring wells and 20 Simulprobe grab samples, Site-related groundwater impacts have been delineated, and impacts from off-Site sources have been documented. Details of the Site-wide groundwater assessment are included in the Site-Wide Groundwater Assessment Report (Haley & Aldrich, 2002a). The following sections summarize the Site-perimeter groundwater impacts in the B-Sand and C-Sand for the purpose of developing the Site-wide groundwater monitoring program.

3.3.1 Site-Perimeter B-Sand

Site-wide perimeter groundwater primary and secondary VOC impacts have been delineated in the B-Sand through a combination of groundwater monitoring wells and Simulprobe grab samples (Figures 5 through 11). The primary VOC present is TCE, found at a maximum concentration of 10,000 µg/l in DAC-P1 along the western Site boundary. The impacts in this well are believed to be from the ILM TCE plume immediately to the west of the Site. Wells BL-9A, BL-10A, and BL-11A were recently installed by TRC, and sampled in September 2002. The TRC wells were reported to have TCE concentrations of 120, 34, and 220µg/l, respectively (TRC, 2002) (Figure 5). This was the initial sampling of these wells, and the results will be confirmed in subsequent monitoring and sampling events. However, the data has been reviewed within the context of the Former C-6 Facility source areas and does not change any recommendations at this time.

A TCE concentration of 850 µg/l is also present in TMW-10, along Normandie Avenue. It is believed that the TCE impacts in this area may be from the Del Amo site immediately to the east.

Chloroform and chlorobenzene concentrations are also present at concentrations of 18,000 µg/l and 100,000 µg/l respectively in Simulprobe grab sample DDS-2-29 along the southern Site boundary. The concentration gradient, distribution, and shape of the chloroform/ chlorobenzene impacts suggest that the Montrose site is the source of these impacts (Haley & Aldrich, 2002a).

Concentrations of TCE and secondary VOCs in the perimeter wells are significantly lower than concentrations in the Building 1/36 and Building 2 source areas (Figures 5 and 6). 1,1-DCE (a secondary VOC in the Site-Perimeter area) was also detected in Simulprobe grab sample DDS-1-10 at a concentration of 13µg/l. Other secondary VOCs were not detected in the Site-perimeter wells. Details of the Site groundwater assessment are included in the Site-Wide Groundwater Assessment Report (Haley & Aldrich, 2002a).

3.3.2 Site-Perimeter C-Sand

Site-wide perimeter groundwater primary and secondary VOC impacts have been delineated in the C-Sand through eight depth-discrete Simulprobe grab samples (Figures 7 and 8). No groundwater monitoring wells are currently present in the C-Sand. The predominant VOC present is TCE, found at a maximum concentration of 1,400 µg/l in Simulprobe grab sample DDS-2-22 along the southern Site boundary. Chloroform and chlorobenzene concentrations are also present at concentrations of 1,100 µg/l and 5,700 µg/l respectively in Simulprobe grab sample DDS-2-29 along the southern Site boundary. These impacts are also believed to be from the Montrose Site (Haley & Aldrich, 2002a).

Concentrations of TCE and other primary VOCs in the perimeter wells are significantly lower than concentrations in the Building 1/36 and Building 2 source areas (Figures 7 and 8). Maximum concentrations of other secondary VOCs were also detected in Simulprobe grab sample DDS-1-10: 1,1-DCE (410 µg/l) and cis-1,2-DCE (8.6 µg/l). Details of the Site groundwater assessment are included in the Site-Wide Groundwater Assessment Report (Haley & Aldrich, 2002a).

Wells BL-9B, BL-10B, and BL-11B were recently installed by TRC and sampled in September 2002. The TRC wells were reported to have TCE concentrations of 33, 140, and 2,800μg/l, respectively (TRC, 2002) (Figure 7). This was the initial sampling of these wells, and the results will be confirmed in subsequent monitoring and sampling events. However, the data has been reviewed within the context of the Former C-6 Facility source areas and does not change any recommendations at this time.

4.0 GROUNDWATER CONCEPTUAL MODEL

A conceptual model for contaminant transport in groundwater at the Site has been developed based on the following: types of sources, the physical and chemical characteristics of the chemicals present, and the anticipated fate and transport of the chemicals within the impacted media for the purpose of monitoring system design. The following provides the key Site-wide components of the conceptual model, followed by specific fate and transport considerations for the Building 1/36, Building 2, and perimeter areas.

The primary mechanism of primary and secondary VOC fate and transport is groundwater flow. Groundwater flow and fate and transport include the following key components:

- Horizontal groundwater flow is the predominant transport mechanism. This is supported by good correlation of VOC plume shape with the predominant horizontal groundwater flow direction.

- Groundwater flow on the Site is predominantly to the south in the B-Sand, and is reported to be to the southeast in the C-Sand. Horizontal groundwater flow also appears to converge to the center of the Site, based on groundwater elevation contour maps (Appendix D, Haley & Aldrich, 2002a).

- Dispersion and diffusion are secondary but important transport mechanisms, as evidenced by the increase in the lateral extent of the VOC plumes with respect to distance downgradient from the suspected sources. Converging horizontal groundwater flow on the Site has likely minimized the effects of dispersion and diffusion.

- Downward vertical migration appears to be the primary mechanism of impacts penetrating into the C-Sand due to the slight vertical component of groundwater flow. The Middle Bellflower Mud reduces this downward migration in those areas where it is present. Localized differences in permeability of the subsurface materials, plus localized and seasonal differences in the direction of groundwater movement, result in deviations in the plume geometry. In areas where the Middle Bellflower Mud has higher permeability, the primary and secondary VOC plumes appears to "step down" into the C-Sand.

- The calculated groundwater flow rate (5 to 20 feet per year) is due to the overall low permeability of the subsurface materials and shallow hydraulic gradient. This is consistent with the length of the groundwater plumes, considering the time since Site activity began.

- Water chemistry data, including dissolved oxygen (DO) and oxidation reduction potential (ORP), indicate that the overall rate of primary and secondary VOC migration may be further retarded by natural degradation processes. This is supported by the occurrence of the degradation daughter products cis-1,2-DCE and

1,1-DCE in the TCE and 1,1,1-TCA plume areas, respectively. The limited size of the groundwater plumes, and the steep concentration gradients observed for toluene and 2-butonane with respect to the other primary and secondary VOCs also indicate that these compounds may be more actively degrading. Depressed DO and ORP values within the VOC source areas indicate reducing conditions, and suggest that the VOCs are undergoing biotransformation.

- The presence of chlorobenzene in groundwater along the southern Site boundary may be enhancing the rate of primary and secondary VOC degradation, and therefore assisting in maintaining the downgradient limits of the plumes within the Site boundary.

4.1 Building 1/36 Conceptual Model

Components of the Site conceptual model specific to the fate and transport of primary and secondary VOCs in the Building 1/36 area include:

- Groundwater concentrations of primary and secondary VOCs are highest in the upper B-Sand, and significantly decline in the bottom B-Sand and C-Sand units.

- Two source areas exist: one below the former Building 1/36 chemical storage complex, and a second near the depth-discrete Simulprobe location DDS-1-14.

- The observed B-Sand plume length (approximately 1,000 feet) and the predicted plume length (500 to 1,000 feet) appear to correlate well, taking into account the two source areas, a horizontal flow rate of 10 to 20 feet per year, and up to 50 years of Site operations.

- The observed concentrations of TCE in groundwater, along with the lack of observed free-product, suggests that dense non-aqueous phase liquid (DNAPL) is not present.

- The presence of elevated abiotic and biological degradation compounds (1, 1-DCE and cis-1,2-DCE respectively) suggests that natural attenuation processes are actively occurring. Field measurements of DO and ORP reinforce these observations.

- Small vertical hydraulic gradients (0.003 ft/ft) between the B-Sand and C-Sand have been measured. These gradients, combined with diffusion, are likely the predominant mechanisms of VOC transport from the B-Sand to the C-Sand.

- The Middle Bellflower Mud appears to be laterally continuous in the Building 1/36 area, and is likely retarding the vertical migration VOCs to the C-Sand.

- C-Sand impacts are significantly smaller in aerial extent and concentration.

- Although no C-Sand groundwater monitoring wells currently exist, the southeastern plume orientation correlates well with a reported southeastern groundwater flow direction at adjacent sites, and is different from the southern flow in the B-Sand.

4.2 Building 2 Conceptual Model

Components of the Site conceptual model specific to the fate and transport of primary and secondary VOCs in the Building 2 area include:

- Groundwater concentrations of primary and secondary VOCs are highest in the upper B-Sand, and significantly decline in the bottom B-Sand.

- One main source area has been identified below a former Building 2 clarifier and metal treatment area. Smaller low-concentration source areas may also exist within the former Building 2 area (Haley & Aldrich, 2002a).

- Horizontal groundwater flow in the Building 2 area is predominantly to the southeast. The overall plume orientation correlates well with the observed groundwater flow direction.

- The observed B-Sand plume length (approximately 1,400 feet) and the predicted plume length (500 to 1,000 feet) do not appear to correlate well, taking into account the single source area assuming a horizontal flow rate of 10 to 20 feet per year, and up to 50 years of Site operations. The presence of multiple lower-concentration sources in the former Building 2 area could explain the observed plume size and distribution (Haley & Aldrich, 2002a).

- Concentrations of TCE in groundwater, along with the lack of observed free-product, suggests that DNAPL is not present.

- The lower concentrations of abiotic and biological degradation compounds (1, 1-DCE and cis-1,2-DCE respectively) suggest that natural attenuation processes are occurring, but at a lower rate than those observed at the Building 1/36 area. Field measurements of DO and ORP reinforce these observations.

- Elevated C-Sand impacts are not present below the source area, but occur approximately 750 feet downgradient of the source area.

- The Middle Bellflower Mud is significantly thinner in the Building 2 and southern portions of the site, and may not be laterally continuous. It is possible that this thinning or even absence of the Middle Bellflower Mud allowed the B-Sand plume to "step-down" into the C-Sand.

- The presence of small vertical hydraulic gradients (0.003 ft/ft) between the B-Sand and C-Sand measured in the Building 1/36 area, combined with the thinning or absence of the Middle Bellflower Mud and VOC diffusion, are likely the predominant mechanisms of transport of VOCs from the B-Sand to the C-Sand.

- Although no C-Sand groundwater monitoring wells currently exist, the southeastern plume orientation appears to correlate well with a reported southeastern groundwater flow direction at adjacent sites.

4.3 Site-Perimeter Groundwater Conceptual Model

Components of the Site conceptual model specific to the fate and transport of primary and secondary VOCs along the perimeter of the Site include:

- Groundwater concentrations of primary and secondary VOCs are delineated, and are generally near the maximum contaminant levels (MCLs) along the Site perimeter, with the highest concentrations present in the upper B-Sand.

- Horizontal groundwater flow in the B-Sand enters the Site from the north, along 190th Street. Groundwater flows onto the Site from the northwest along the western Site perimeter, and from the northeast along the easter Site perimeter (Normandie Avenue). These groundwater flow directions result in an overall groundwater flow direction to the south, with convergence towards the center of the Site.

- Elevated primary VOCs in DAC-P1 along the western Site boundary are believed to be from groundwater impacts at the former ILM site.

- Elevated primary VOCs in TMW-10 along the eastern Site boundary are possibly from groundwater impacts at the former Del Amo site.

- Elevated chloroform/chlorobenzene concentrations along the southern Site perimeter are believed to be from groundwater impacts at the former Montrose Chemical site.

- The presence of biological degradation compounds (cis-1,2-DCE) suggests that natural attenuation processes are actively occurring along the southern Site perimeter. Field measurements of DO and ORP reinforce these observations. These processes could be contributing to containment of the primary and secondary VOC plumes on the Site.

5.0 PROPOSED GROUNDWATER MONITORING NETWORK

Using the groundwater characterization results and conceptual groundwater model discussed above, a groundwater monitoring well network is proposed to accomplish the groundwater monitoring goals stated in Section 1. This groundwater monitoring well network will consist of existing groundwater monitoring wells, LARWQCB-approved groundwater remediation monitoring wells to be installed (Arcadis G&M, 2001, 2002a, 2002b), and proposed groundwater monitoring wells. Groundwater monitoring well sampling is provided in the annual Groundwater Monitoring Work Plan, submitted to the LARWQCB each December for the upcoming year.

Since the Site is currently undergoing various stages of redevelopment construction and planning, existing groundwater monitoring wells may need to be abandoned, and proposed monitoring well locations may need to be adjusted. The LARWQCB will be notified of such changes as necessary, and appropriate documentation will be subsequently provided.

The following sections discuss the specific B-Sand and C-Sand groundwater monitoring needs and proposed monitoring network for the Building 1/36 source area, the Building 2 source area, and the Site-perimeter monitoring.

5.1 Building 1/36 Source Area

5.1.1 Building 1/36 B-Sand

There are 9 existing groundwater monitoring wells in the Building 1/36 B-Sand area. Additionally, five bioremediation monitoring wells have been approved by the LARWQCB as part of the Building 1/36 bioremediation program for installation. However, not all of the Site-wide groundwater monitoring objectives can be met with these 16 wells. Objectives not met include:

- No Building 1/36 source area upgradient groundwater monitoring location
- No Building 1/36 source area immediately downgradient groundwater monitoring location

To meet this objective, two additional B-Sand groundwater monitoring wells (MWB008 and MWB010) are proposed, as indicated in Table 1 and Figure 12. Well construction details are provided in Table 1. Installation will be coordinated with Site redevelopment plans and schedules.

5.1.2 Building 1/36 C-Sand

No groundwater monitoring wells currently exist in the Building 1/36 source-area C-Sand at the Site. Four C-Sand bioremediation monitoring wells have been approved for installation by the LARWQCB. Building 1/36 source-area groundwater monitoring objectives not met with these four wells include:

- Crossgradient groundwater monitoring wells do not exist
- A downgradient groundwater monitoring well does not exist
- Groundwater gradients and flow within the C-Sand are unknown

To meet these objectives, three additional C-Sand groundwater monitoring wells are proposed, as indicated in Table 1 and Figure 13. These wells include MWC009, MWC04D and MWC011 to address the objectives above respectively. Well construction details are provided in Table 1. Installation will be coordinated with Site redevelopment plans and schedules.

5.2 Building 2 Source Area

5.2.1 Building 2 B-Sand

A total of three groundwater monitoring wells are currently present in the Building 2 source area B-Sand (Figure 12). Additionally, four bioremediation monitoring wells have been approved by the LARWQCB as part of the Building 2 bioremediation program for installation (Arcadis G&M, 2001 and 2002b). However, not all of the Site-wide groundwater monitoring objectives can be met with these eight wells. Objectives not met include:

- An upgradient groundwater monitoring well does not exist

- A downgradient plume constraint does not exist

- Groundwater monitoring wells to separate Building 1/36 and Building 2 plumes does not exist

To meet these objectives, three additional B-Sand groundwater monitoring wells are proposed, as indicated in Table 2 and Figure 12. These wells include MWB012, MWB013 and MWB014. Well construction details are provided in Table 2. Installation will be coordinated with Site redevelopment plans and schedules.

5.2.2 Building 2 C-Sand

No groundwater monitoring wells currently exist in the Building 2 source-area C-Sand at the Site. Three C-Sand bioremediation monitoring wells have been approved for installation by the LARWQCB. Building 2 source-area groundwater monitoring objectives not met with these three wells include:

- An upgradient groundwater monitoring well does not exist
- Crossgradient groundwater monitoring wells do not exist
- Groundwater gradients and flow within the C-Sand is unknown

To meet these objectives, three additional C-Sand groundwater monitoring wells are proposed, as indicated in Table 2 and Figure 13. These wells include MWC015, MWC016 and MWC017 to address the objectives above respectively. Well construction details are provided in Table 1. Installation will be coordinated with Site redevelopment plans and schedules.

5.3 Site-Perimeter Groundwater

5.3.1 Site-Perimeter B-Sand

The existing B-Sand Site-perimeter groundwater monitoring well network of nine groundwater monitoring wells satisfies the Site-wide groundwater monitoring program goals, with the exception of monitoring the northern and southern Site boundaries as follows:

- The well currently used to monitor the chloroform/chlorobenzene plumes along the southern Site boundary, originating from the former Montrose facility, is scheduled to be abandoned in the winter of 2003 due to Site redevelopment.

- No northern Site boundary well exists due to abandonment of WCC-11S

To provide southern Site perimeter monitoring, two additional B-Sand groundwater monitoring wells are propsed, as indicated in Table 3 and Figure 12. These wells include MWB019 and MWB020 to address the objectives above respectively. Well construction details are provided in Table 3 and Figure 12. Installation will be coordinated with Site redevelopment plans and schedules.

5.3.2 Site-Perimeter C-Sand

No groundwater monitoring wells currently exist in the Building 2 source-area C-Sand at the Site. Two C-Sand bioremediation monitoring wells have been approved for installation by the LARWQCB. Site-perimeter groundwater monitoring objectives not met with these two wells include:

- Flow of groundwater in C-Sand at the eastern and southern Site boundaries is presently unknown

- No downgradient/perimeter monitoring location along the eastern Site boundary near the former Del Amo site

To meet these objectives, one additional C-Sand groundwater monitoring well (MWC021) is proposed. Well construction details are provided in Table 3 and Figure 13. Installation will be coordinated with Site redevelopment plans and schedules.

6.0 GROUNDWATER MONITORING WELL INSTALLATION

6.1 Drilling

The B-Sand groundwater monitoring wells will be advanced using a hollow stem auger drilling rig to approximately 85 to 90 feet bgs. The C-Sand groundwater monitoring wells will be advanced using a temporary steel casing-type drilling method such as air rotary casing hammer (ARCH) or rotosonic drilling to approximately 115 to 125 feet bgs. Drilling depths in Tables 1 through 3 are approximate, and will be adjusted in the field based on lithology.

6.2 Permits

Prior to drilling activities, permits will be obtained from the Los Angeles County Department of Health Services for each groundwater monitoring well.

6.3 Groundwater Monitoring Well Installation and Surveying

The wells will be constructed using 4-inch outside diameter (OD) Schedule-40 polyvinyl chloride (PVC) casing. The wells will contain 20 to 25 feet of 0.020-slotted screen. Screen intervals for each well are included on Tables 1 through 3. The annular space between the formation and the slotted casing will be filter packed using #3 Monterey sand to approximately 2 feet above the top of the perforated zone. A bentonite seal will be placed on top of the filter pack to a thickness of approximately 3 feet, and the remaining annular space will be sealed with a cement grout. The top of the well will be completed using a 12-inch-diameter steel traffic-rated vault secured in a concrete apron. The top of the well casing inside the vault will be covered with a locking PVC cap. Drilling and well depths will be adjusted in the field based on lithology.

The wells will be developed by surging, bailing, and/or pumping as appropriate. The wells will be monitored and sampled no sooner than 72 hours after installation. After the groundwater monitoring wells have been installed, the well casing location and elevation will be surveyed to the Site benchmark.

6.4 Residuals Management

Residuals generated during the investigation program will include soil cuttings, drilling mud and groundwater monitoring well development, and purge water. Soil cuttings and drilling mud generated during the drilling will be placed in lined and covered roll-off bins. Upon completion of drilling activities, the soil and drilling mud will be sampled and characterized for disposition in accordance with Site soil disposition protocols.

Groundwater monitoring well development and purge water will be contained in 55-gallon drums and labeled. Upon completion of field activities, the water will be characterized for proper off-Site disposition by Boeing.

6.5 Health and Safety

Personnel completing the work will be 40-hour Occupational Health and Safety Administration (OSHA)-certified, and will use Level D protection. Work will be conducted in accordance with the Site-specific Health and Safety Plan dated June 8, 2001 and updated November 12, 2001 and October 30, 2002.

7.0 GROUNDWATER SAMPLING

The wells will be monitored and sampled according to the procedures set forth in the Site-Wide Groundwater Monitoring Workplan 2003 (Haley & Aldrich, 2002c) and the monitoring requirements of the bioremediation Waste Discharge Requirement (WDR) permit.

The wells will be sampled within two weeks following installation and sampled quarterly for three additional events following. After the first four events, the wells will be sampled semi-annually.

8.0 SCHEDULE

The propsed wells will be installed in phases as Site redevelopment and groundwater remediation installation progresses in 2003 to prevent removal and re-installation. The LARWQCB will be notified of significant changes to this proposed program and an appropriate addendum will subsequently be provided.

9.0 REPORTING

The groundwater monitoring analytical data will be added to the annual and semi-annual groundwater monitoring reports as the new wells are installed. The annual and semi-annual monitoring events occur in March and September of each year, with report submittals to the RWQCB occurring 60 days after field monitoring. The annual and semi-annual groundwater reports are submitted to the LARWQCB in May and November of each year.

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